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Bureau of Entomology and Plant Quarantine

THE NEW INSECTICIDES FOR CONTROLLING EXTERNAL PARASITES OF LIVESTOCK

By Division of Insects Affecting Man and Animals

Since 1945, when DDT first came into use for controlling insects and ticks on livestock, several new insecticides have been developed which are now available to the public for the control of those pests. These insecticides are benzene hexachloride, chlordane, chlorinated camphene, methoxychlor, TDE, and piperonyl butoxide. The Bureau of Entomology and Plant Quarantine has during this short period endeavored to appraise the merits of these new materials for controlling various external parasites of farm animals. Although there is need for further investigations on the use of these new insecticides, the great demand for information already obtained by the Bureau has prompted the issuance of this preliminary report. Certain data obtained in cooperation with other agencies are included.

The major objectives of this report are (1) to summarize the results of research which has been conducted to date and, insofar as possible, to compare the performance of the different materials against various livestock pests; (2) to summarize briefly the available knowledge regarding the toxicity of the materials to animals; and (3) to issue guiding statements as to how the new materials may be employed if their use is warranted at this time. The Bureau is reluctant to offer such guiding statements at this time, but the materials are available and are being used by livestock growers in some cases without regard to the hazards involved and without the benefit of available knowledge regarding their effectiveness.

Because of the many insecticides and insecticide preparations currently available to the public for the control of several livestock pests, it is extremely important to determine which materials to employ for maximum efficiency, safety, and economy. Consideration must be given to the parasites involved, the types of animals, methods of application, stability of specific formulations, and other factors.

RESULTS OF TESTS WITH VARIOUS INSECTICIDES

Benzene Hexachloride

Benzene hexachloride has been tested rather extensively by State and Federal agencies, commercial companies, and other institutions associated with the livestock industry. It is generally available in the form of wettable powders and dusts and less generally as solutions and emulsion concentrates. The technical product consists of several

isomers and usually contains 10 to 12 percent of the gamma isomer, which is the most active one. Most wettable powders contain 50 percent of technical benzene hexachloride, or 5 to 6 percent of the gamma isomer. Some manufacturers are now producing grades that contain up to 95 percent of the gamma isomer.

The insecticide is a crystalline product with a persistent musty odor. This objectionable odor is less intense in some of the products of high gamma content.

Wettable-powder preparations have been used in most of the tests, but xylene emulsions have also been tested. In general no marked difference in effectiveness has been noted in the two forms. Benzene hexachloride is a contact insecticide, but it also has some fumigating action.

Cattle Lice

From the standpoint of initial killing action, benzene hexachloride is among the most effective insecticides for controlling lice on cattle. It kills the eggs as well as the motile forms by contact, and it also acts as a fumigant.

Benzene hexachloride has been tested against the short-nosed cattle louse (Haematopinus eurysternus (Nitz.)), the long-nosed cattle louse (Linognathus vituli (L.)), and the tail louse (H. quadripertusus Fahr.). Complete control of the first two species was obtained when animals were thoroughly sprayed with 0.5 percent of technical benzene hexachloride (0.05 to 0.06 percent of the gamma isomer) in wettable-powder sprays. A single thorough treatment with 0.25 percent of the technical material has given good control, but in tests conducted in Texas this concentration did not always give complete control. Both concentrations have given good initial control of the tail louse in a limited number of tests. Apparently complete control of this species has been obtained with a 1-percent spray.

Goat Lice

Wettable-powder and emulsion dips of technical benzene hexachloride have been tested against red and yellow goat lice (Bovicola spp.) on Angora goats. At 0.2-percent concentration a single dipping eliminated lice from the herd. Excellent initial control was obtained with 0.05-percent dips, but several months after treatment a few lice were present. DDT at the same concentrations has given similar results.

Hog Louse

Benzene hexachloride is also effective against the hog louse (Haematopinus adventicius Neum.). A single thorough treatment with 0.2 percent of the technical material has given good but not complete control in a limited number of tests. Other workers have reported complete control at 0.5-percent concentration.

Sheep Tick

In Oregon dips containing 0.05, 0.2, and 0.5 percent of technical benzene hexachloride have provided complete control of the sheep tick (Melophagus ovinus (L.)). Thorough treatments with 0.2-percent sprays (4 to 6 quarts per mature sheep with long fleece) were effective in limited tests, but complete control was not effected until several weeks after treatment. Ground derris (rotenone 5 percent), at rates of 4 and 8 ounces in 100 gallons of dip, also gave complete control of this insect. Rotenone as a dip seems to be the most economical treatment for controlling this pest, and from this standpoint is superior to any of the new insecticides.

Lone Star Tick

Benzene hexachloride has been tested against the lone star tick (Amblyomma americanum (L.)) on cattle at concentrations from 0.1 to 1.5 percent of the technical product. It has killed all stages of the tick at concentrations as low as 0.25 percent. However, even at 1.5 percent the residual action has not been marked. At Kerrville, Tex., a 0.5-percent spray protected animals for about 4 days, but after 1 week some ticks were beginning to engorge. Concentrations higher than 0.5 percent did not seem to prolong the protection to any marked degree. In comparative tests DDT failed to kill all engorged ticks at a concentration as high as 1.5 percent. However, DDT provided better protection against reinfestation than did benzene hexachloride. After 2 weeks the control obtained with sprays containing 0.5 and 0.75 percent of DDT was comparable with that obtained after 1 week with similar concentrations of benzene hexachloride. The 0.75-percent DDT spray provided about 75 percent protection for 2 weeks.

Winter Tick

Sprays containing benzene hexachloride have been tested on cattle and sprays or washes on horses for control of the winter tick (Dermacentor albipictus (Pack.)) in the vicinity of Kerrville. Good control of all stages resulted at a concentration as low as 0.1 percent of technical benzene hexachloride. Concentrations of 0.25 and 0.5 percent protected animals against reinfestation for about 2 weeks. DDT emulsions and wettable powders failed to kill all engorged ticks at concentrations up to 2.5 percent, but 0.5- to 0.75-percent concentrations provided protection for about 4 weeks.

Ear Tick

In laboratory and field tests benzene hexachloride was effective against the ear tick (Otobius megnini (Duges)) when applied as a spray. However, little is known about the most practical concentrations required to control this species or about the duration of effectiveness.

Flies

Benzene hexachloride is highly toxic to the horn fly (Siphona irritans (L.)) and the house fly (Musca domestica L.), but its residual

action is not sufficient to effect lasting control. Sprays applied on cattle for the control of horn flies at concentrations of 0.25 to 0.5 percent generally become ineffective in 3 to 4 days as compared with 3 to 4 weeks for DDT. In laboratory tests conducted at Orlando, Fla., deposits of benzene hexachloride up to 400 mg. per square foot failed to give complete control of house flies exposed for 2 hours 9 weeks after treatment, whereas DDT applied at rates from 50 to 400 mg. per square foot was completely effective at the end of 36 weeks.

Benzene hexachloride has been reported to provide some control of horse flies and deer flies. In tests conducted in Texas against Tabanus abactor Philip, all flies feeding on treated cattle for 1 to 2 days after spraying were killed. In Georgia some success against tabanids was indicated with mixtures of benzene hexachloride and methoxychlor. The destruction of tabanids that feed on treated animals during the indicated short period of effectiveness might reduce the population sufficiently to provide some control. However, further study is necessary to determine the value of benzene hexachloride in practical control of these pests.

Screw-Worm and Fleece Worms

Benzene hexachloride is highly effective as a larvicide for the screw-worm (Callitroga americana (C. and P.)) and fleece worms (Phormia regina (Meig.) and other secondary blow flies). However, insufficient tests have been conducted to determine its value as a practical control measure.

Common Cattle Grub

Benzene hexachloride in certain tests has given some kill of the common cattle grub (Hypoderma lineatum (De Vill.)). Its performance is erratic, however, and available formulations cannot be depended upon to provide satisfactory control at concentrations that are considered feasible from the standpoint of economy or safety.

Chlordane

Chlordane has been employed extensively for the control of certain household pests. It is a viscous liquid, readily soluble in a number of solvents, including petroleum oils. Recently chlordane has been offered for sale for the control of various livestock pests. Rather extensive tests have been conducted with this insecticide against most of the major pests of livestock. Both a wettable-powder preparation and emulsions have been used. Under some conditions chlordane exhibits a fumigating property in addition to its usual contact action.

Cattle Lice

Chlordane, in both wettable-powder (50 percent) and emulsion-concentrate (25 to 50 percent) formulations, has been compared with DDT against several species of lice on cattle. It is indicated to be equal to DDT for controlling these insects. Complete control of both

long-nosed and short-nosed lice was obtained with 0.5-percent sprays. A 0.25-percent spray gave good but not complete control of lice with one treatment. The tail louse also appeared to be equally as susceptible to chlordane as to DDT. The concentration needed for practical or complete control has not been determined, but a 1-percent chlordane spray gave complete control in one test.

Goat Lice

Chlordane and DDT were found to be equally effective against red and yellow goat lice in tests conducted in Texas. A 0.2-percent dip, prepared from either wettable powder or emulsion concentrate, provided complete control, and no reinfestation occurred for at least 4 months. At 0.05-percent concentration both materials controlled all motile forms, but some animals were found infested when examined 4 months later.

Hog Louse

In one test with a few animals chlordane gave apparently complete control of hog lice when applied as a wettable-powder spray at 0.2-percent concentration. DDT in the same test gave good initial control, but a few lice were found after 3 weeks.

Sheep Tick

Dips containing 0.05, 0.2, and 0.5 percent of chlordane gave complete control of sheep ticks. DDT also gave complete control, but chlordane eliminated the emerging adults more quickly. When applied as a spray at 0.2-percent concentration, chlordane was superior to DDT and comparable with benzene hexachloride.

Lone Star Tick

Chlordane has been tested against the lone star tick on goats and cattle at concentrations of 0.25, 0.5, 0.75, and 1.5 percent. All concentrations gave complete or almost complete control of the flat stages, and the 0.75- and 1.5-percent concentrations caused nearly complete kill of all stages. DDT failed to kill all the engorged forms at 1.5-percent concentration. At the same concentrations the two insecticides gave about equal protection against reinfestation. (The performance of DDT in these tests has been mentioned in the discussion of benzene hexachloride for tick control.)

Winter Tick

Chlordane is distinctly superior to DDT against the winter tick on cattle and horses. Complete or nearly complete control of all stages has been obtained with 0.75-percent sprays, whereas DDT at 1.5 percent killed only a small percentage of the engorged forms. Chlordane is also superior to DDT from the standpoint of protection against reinfestation. At 0.5 and 0.75 percent chlordane prevented reinfestation for about 2 months as compared with 1 month for DDT. Chlordane as a 5-percent dust has also given good control of winter ticks and proved superior to DDT.

Flies

Chlordane has been tested on animals exposed to horn flies in cages, and in field tests on dairy animals in Texas and beef animals in Kansas. The tests in Kansas were conducted in cooperation with the experiment stations and State colleges of Kansas and Missouri, and with the Livestock Loss Prevention Board of Kansas City. Wettable-powder sprays at concentrations of 0.25 and 0.5 percent, applied at approximately 2 quarts per mature animal, gave good control of horn flies and protected the animals for about 3 and 4 weeks, respectively. There was no clear-cut difference in effectiveness between DDT and chlordane, but chlordane appeared to be slightly inferior.

Chlordane is more toxic than DDT to house flies. Its residual action is long lasting but not equal to that of DDT. In laboratory tests at Orlando, Fla., surface treatments at the rate of 200 mg. of chlordane per square foot, applied in acetone solution, gave complete or almost complete kill of flies exposed for 2 hours as long as 28 weeks after treatment. DDT, however, was still completely effective after 36 weeks, even at the low rate of 50 mg. per square foot. Recently, reports of failure of DDT to control house flies have been received. Limited field tests have shown promise for chlordane as a substitute for DDT in such situations.

Chlordane applied as a 1- to 2-percent emulsion was effective for about 1 day against tabanids feeding on treated livestock.

Screw-Worm and Fleece Worms

Chlordane is one of the most effective insecticides tested against screw-worm larvae, and it also protects sheep from attack by fleece worms. However, insufficient tests have been conducted to determine its potential uses for controlling these insects.

Common Cattle Grub

When emulsion and wettable-powder formulations containing up to 1.5 percent of chlordane were applied to cattle, both as a wash and with a high-power sprayer, the mortality of cattle grubs was less than 20 percent. Dusts containing up to 5 percent of chlordane also proved ineffective.

Chlorinated Camphene

Technical chlorinated camphene is a waxy, crystalline material. It has no objectionable odor, and is readily soluble in most of the common solvents used in insecticide formulations, including petroleum oils. It is one of the newest insecticides being offered to the public for livestock-pest control. In most of the tests wettable-powders and emulsion concentrates were used. The wettable powders contained from 25 to 40 percent of the toxicant, and the emulsion concentrate from 25 to 65 percent with xylene or kerosene as the solvent.

Cattle Lice

When tested at concentrations of 0.25 and 0.5 percent, chlorinated camphene gave results that were comparable with those obtained with DDT, benzene hexachloride, and chlordane against both short- and long-nosed cattle lice and the tail louse.

Goat Lice

Chlorinated camphene appeared to be at least equal, and perhaps superior, to DDT, chlordane, and benzene hexachloride against red and yellow goat lice. In limited tests apparently complete control was obtained with dips containing 0.05 percent or a slightly lower concentration of the insecticide. Dips at 0.2-percent concentration have kept goats free of lice for at least 4 months.

Hog Louse

Only one test, involving a few animals, has been run with chlorinated camphene against the hog louse. A wettable powder at 0.2-percent concentration gave apparent complete control of the lice, being superior to DDT and comparable with chlordane.

Sheep Tick

Against the sheep tick chlorinated camphene appeared to be superior to DDT when used as either a dip or a spray, but less effective than benzene hexachloride and chlordane. In a few tests complete control was obtained with dips containing 0.05, 0.2, and 0.5 percent of the insecticide. However, its action appeared to be slower than that of the other insecticides.

Lone Star Tick

Chlorinated camphene proved superior to DDT and equal to chlordane, but less effective than benzene hexachloride, against the engorged forms of the lone star tick. Its residual effect provided protection against reinfestation comparable with that given by DDT and chlordane. Sprays at 0.75-percent concentration gave good control of all stages and protection against reinfestation for 2 weeks, comparable with that given by DDT and chlordane.

Winter Tick

Chlorinated camphene was superior to DDT and comparable with chlordane against the winter tick on cattle and horses, when employed either as a spray or as a dust. Good control of all stages was obtained with sprays containing as little as 0.75 percent. This concentration protected against reinfestation for about 2 months. A 0.5-percent spray failed to control all the engorged forms, but prevented further reinfestations for 6 to 8 weeks.

Ear Tick

Chlorinated camphene was superior to DDT and comparable with chlor-dane and benzene hexachloride for controlling the ear tick. However, further studies are needed to determine its value for this purpose.

Flies

Chlorinated camphene at 0.5-percent concentration has given results similar to DDT for the control of horn flies. Although it is somewhat slower in killing flies coming to treated animals, and under certain conditions might appear to be inferior, final control has in general been comparable with that obtained with DDT.

Chlorinated camphene was less effective than DDT against house flies, from the standpoint of both initial killing action and residual action. Little information is available on the relative efficiency of the two materials against stable flies. Chlorinated camphene did not protect animals from attack by tabanids.

Screw-worm and Fleece Worms

Chlorinated camphene was highly effective against young screw-worm larvae and the larvae of fleece worms. It provided excellent protection against fleece worm attack on sheep, when used at 2-percent concentration. However, little is known about the value of this material for controlling either of these parasites under practical conditions.

Common Cattle Grub

In small-scale tests chlorinated camphene did not control larvae of the common cattle grub.

Methoxychlor

Methoxychlor (also called the methoxy analog of DDT) is similar to DDT in both physical and chemical properties. Most of the tests have been made with 50-percent wettable powders and 25-percent emulsion concentrates, in general with equal effectiveness.

Cattle Lice

Sprays containing 0.5 percent of methoxychlor gave good control of short-nosed and long-nosed cattle lice and the tail louse in some, but not all tests.

Hog Lice

Methoxychlor was effective against the hog louse and perhaps comparable with DDT, but a single treatment with 0.2-percent spray did not give complete control.

Ticks

Against ticks methoxychlor was less effective than the other chlorinated hydrocarbon insecticides. Wettable-powder sprays up to 1.5 percent did not kill unengorged and engorged winter ticks and lone star ticks on cattle and horses, and animals became reinfested by the second week. In laboratory dipping tests it was inferior against the lone star tick and the ear tick. In tests in Oregon, however, it controlled sheep ticks when employed as a dip at 0.2- and 0.5-percent concentrations.

Flies

Methoxychlor gave good control of the horn fly on cattle. A 0.5-percent wettable-powder spray (2 quarts per mature animal) applied to dairy cattle in Texas and to beef cattle in Kansas provided 20 to 24 days' protection, as compared with 28 to 30 days for DDT. In Missouri both materials protected animals for about 6 to 7 weeks. Tests on treated animals exposed to flies in cages indicate that this material is slightly inferior to DDT.

In laboratory and small-scale field tests methoxychlor was effective against house flies and stable flies. Although generally its residual effectiveness was of shorter duration, under certain conditions it was superior to DDT. Preliminary tests in Texas and in Georgia indicate that this insecticide, alone and with benzene hexachloride, offers some promise in controlling tabanids.

TDE

TDE (also called DDD) is a crystalline substance closely related to DDT in chemical and physical properties. The types of formulations used are also similar to those of DDT. Tests conducted with both emulsion and wettable-powder formulations have thus far shown no difference in effectiveness.

Cattle Lice

TDE was about equal to the other chlorinated insecticides for the control of short-nosed and long-nosed cattle lice, and also of the tail louse. A 0.5-percent spray thoroughly applied gave good control of the first two insects.

Hog Lice

In preliminary tests run on a few hogs for the control of the hog louse, TDE was equal to DDT in initial kill. Neither material gave complete control at 0.2-percent concentration.

Sheep Tick

TDE gave good control of sheep ticks when employed as a dip at concentrations of 0.2 and 0.5 percent. It was about equal to methoxychlor but less effective than the other chlorinated hydrocarbon insecticides.

Ticks

In laboratory dipping tests against the lone star tick TDE was not so effective as chlordane, benzene hexachloride, chlorinated camphene, or DDT.

In a limited number of tests against the winter tick TDE was approximately equal to DDT but inferior to chlorinated camphene and chlordane. Sprays containing 0.5 to 0.75 percent of TDE did not kill engorged ticks but prevented reinfestations for about 1 month.

Flies

TDE gave satisfactory control of horn flies on beef and dairy animals. In general at 0.5-percent concentration (in a wettable powder) this material was about equal to methoxychlor and slightly less effective than DDT and chlorinated camphene.

In laboratory tests TDE was less effective than DDT against house flies and stable flies.

Piperonyl Butoxide

Piperonyl butoxide alone is somewhat insecticidal, but it is of chief interest for use in combination with pyrethrum, which is widely used in cattle fly sprays. The insecticidal action of pyrethrum is rapid and it is safe for use on warm-blooded animals, but it is costly and is unstable. The addition of piperonyl butoxide to pyrethrum increases the insecticidal action, and the duration of its effectiveness.

Emulsions containing 0.005 percent of pyrethrins and 0.05 percent of piperonyl butoxide, or 0.01 percent of pyrethrins and 0.1 percent of piperonyl butoxide, gave complete initial control of the short-nosed cattle louse, but young lice were present on the treated animals after 2 weeks.

The pyrethrum-piperonyl butoxide sprays provided considerable protection to animals against stable flies for several days. Some protection against tabanids was also indicated, although results reported by several investigators vary considerably with respect to duration of protection against different species. Not enough research has been conducted for conclusions to be drawn regarding their effectiveness against livestock pests in general.

TOXICOLOGICAL INVESTIGATIONS

The Food and Drug Administration is investigating the toxicity of the various new insecticides to laboratory animals. The Bureau of Entomology and Plant Quarantine, in cooperation with the Bureau of Animal Industry and the Texas Agricultural Experiment Station, is conducting certain toxicological studies on livestock.

The references to the toxicity of the insecticides to small laboratory animals are taken from a recent paper by A. J. Lehman ^{1/}, pharmacologist in the Food and Drug Administration. The data represent general averages for several kinds of laboratory animals. Since most of the studies are incomplete, and many of the formulations differed from those employed in treating livestock, the information indicates trends or approximate toxicity only.

The Bureau is conducting toxicological investigations (1) to determine the effects on livestock of various materials when applied externally and (2) to determine the amount of insecticide secreted in milk when applied to dairy animals in amounts and frequency necessary to control horn flies. The tests on livestock are being conducted at Kerrville, Tex., and the chemical analyses at Beltsville, Md. Some studies have also been made to determine whether products from animals treated with benzene hexachloride are tainted with its odor or taste. Investigations on absorption and storage of insecticides in animal tissues resulting from external treatments are under way, but insufficient data are available to include them in this discussion. Chronic-toxicity studies involving repeated treatments of livestock with the various insecticides over a period of years have not been undertaken.

Benzene Hexachloride

The different isomers of benzene hexachloride vary in their toxicity to higher animals. For the gamma isomer the mean lethal dose to laboratory animals, when administered by mouth, is approximately 125 mg. per kilogram of body weight, as compared with about 250 mg. for DDT. In oil solution it is readily absorbed through the skin; when it is administered in this way the mean lethal dose to laboratory animals ranges from 20 to 50 mg. per kilogram. On daily feeding gamma benzene hexachloride is less toxic than DDT, but it is much more toxic when applied to the skin.

At Kerrville high concentrations and frequent treatments were tested to gain information on the upper limits of toxicity. When mature or near mature animals were employed, no harmful effects were noted on 8 sheep, 8 goats, 4 cattle, 2 horses, and 2 hogs treated eight times at 4-day intervals with a dip or spray containing 1.5-percent of technical benzene hexachloride. A wettable-powder preparation was used on some of the animals and a xylene emulsion on the others. The Livestock Loss Prevention Board of Kansas City obtained similar results on 8 animals treated with a wettable-powder spray at the same concentration. At Kerrville 10 cows treated nine times at 2-week intervals with a 2-percent wettable-powder spray were without apparent harmful effects. However, when a wettable powder containing 50-percent of gamma benzene hexachloride was used, all 3 cattle treated once with a spray containing 1.5 percent of the gamma isomer were killed, and 1 out of 3 sprayed with

^{1/} Lehman, A. J. The Toxicology of the New Agricultural Chemicals. Bul. Assoc. Food and Drug Officials 12(3): 82-89. 1948.

0.75-percent gamma died and another was seriously affected but recovered. A 0.25-percent gamma spray had no ill effects.

Calves less than 3 months old are much more susceptible to benzene hexachloride than are cattle a year old or older. Xylene-emulsion sprays containing 0.05 percent of the gamma isomer killed some calves that were thoroughly saturated to simulate dipping. Wettable-powder sprays of the same gamma content were apparently less toxic, but toxic symptoms were evident in two of nine calves treated and one calf died. Few reports of death or injury among calves or cattle have been received following treatment with benzene hexachloride in actual use for pest control. However, these available toxicology data suggest that the margin of safety for benzene hexachloride applied to young calves is extremely narrow.

To determine whether the use of benzene hexachloride gave off-flavor or odor to meats of treated animals, tests were conducted with several kinds of animals. One pig received two thorough treatments 9 days apart with a spray containing 2.5 percent of technical benzene hexachloride. Two days after the second treatment 10 families cooked and tasted the meat. None of the families detected benzene hexachloride taste, but two of them detected the odor while the meat was cooking. Another pig was sprayed twice 4 days apart with 1.5-percent technical benzene hexachloride, and slaughtered on the sixth day. None of the families eating the meat reported benzene hexachloride odor or taste. In similar tests with a goat, a sheep, and a yearling calf one report of benzene hexachloride flavor or odor from each animal was received. Another calf and a pig treated eight times at 4-day intervals with a 1.5-percent spray and slaughtered 1 month after the last treatment showed no marked off-flavor or odor, although some individuals gave positive reports. In tests with six chickens exposed for one to several weeks to roosts heavily painted with a slurry of technical benzene hexachloride, conflicting reports were received but in one chicken marked benzene hexachloride odor was detected.

In these tests the concentration of benzene hexachloride was in excess of that needed for controlling the parasites. In a thorough test conducted in cooperation with the Missouri Agricultural Experiment Station and College, no off-flavor or odor was detected in meat from a cow dipped approximately 18 times during the course of 2 years in a wettable-powder dip containing 0.5 percent of technical benzene hexachloride. No reports of off-flavor or odor of meat from livestock treated with benzene hexachloride for practical pest control have come to the attention of this Bureau.

Chlordane

The acute toxicity of chlordane administered orally to laboratory animals was found to be about half that of DDT. However, the toxicity of a solution applied repeatedly to the skin is reported to be greater for chlordane.

At Kerrville five sheep, five goats, two cattle, and one horse were treated eight times at 4-day intervals with a 1.5-percent chlordane emulsion, and the same numbers of animals were treated with a wettable-powder preparation at the same strength. The test was repeated with a new lot of chlordane, but only five sheep and two pigs were treated with each preparation. In the first test none of the cattle or horses were killed with either preparation, but the sheep and two of the goats were killed by the emulsion and two sheep and two goats by the wettable powder; some of the animals died after the third treatment. In the second test none of the animals were killed.

The Livestock Loss Prevention Board obtained similar results in that sheep were killed by the severe treatment, and one of two cattle sprayed with the emulsion and with the wettable-powder suspension was killed.

In another test at Kerrville three of ten cattle died after four thorough treatments at 2-week intervals with a 2-percent wettable-powder preparation. No explanation can be offered for the variable results.

Weekly analyses of milk samples from two dairy herds sprayed four times with 0.5-percent wettable powder at intervals of about 1 month showed that small amounts of organic chlorine were present in the milk. Of 18 samples analyzed, 17 showed from 0.1 to 0.4 p.p.m. of organic chlorine. However, it is not certain that all the organic chlorine present can be attributed to the chlordane treatment.

Chlorinated Camphene

Chlorinated camphene was found to be about four times as toxic as DDT when administered orally to various laboratory animals. The mean lethal dose of chlorinated camphene, when administered orally to laboratory animals, was about 60 mg. per kilogram. Preliminary tests indicate that livestock are of similar susceptibility. When applied to the skin it is also far more toxic than DDT. Although the insecticide is rather toxic from an acute standpoint, preliminary chronic-toxicity studies reported by the Food and Drug Administration indicate that for certain animals the insecticide taken in the diet in small doses over an extended period of time is not so toxic as certain other insecticides that are more toxic on the basis of single acute doses.

When 20 sheep, 15 goats, 8 cattle, 4 horses, and 4 hogs, all mature or nearly mature, were treated eight times at 4-day intervals with 1.5 percent of chlorinated camphene, no adverse effects were noted on any of the animals.

However, young calves are more susceptible to this insecticide. After reports of its toxic effect on calves in Texas, tests were made on calves 1 to 2 months old. A single spraying with 1.5-percent emulsion (containing xylene and kerosene) or wettable-powder suspension caused toxic symptoms on some of the treated calves, and two treatments 4 days apart caused a few deaths. Single treatments of 0.75-percent concentration had no adverse effects on 12 calves.

Milk samples from dairy herds treated four times at about monthly intervals with 0.5-percent wettable-powder sprays were analyzed for organic-chlorine content. Of 43 samples analyzed, 27 were negative. When the results were positive, the amounts of organic chlorine ranged from 0.2 to 0.6 p.p.m. It is not certain that the organic chlorine present can be attributed to the chlorinated camphene.

Methoxychlor

Methoxychlor is the least toxic of the chlorinated hydrocarbon insecticides that have been investigated. The mean lethal dose to various laboratory animals when administered orally was about 6 ~~mg.~~ ^{grams} per kilogram of body weight. Preliminary feeding tests also suggest a low chronic toxicity.

At Kerrville no adverse effects were noted when five sheep, five goats, two cattle, two hogs, and one horse were treated eight times at 4-day intervals with an emulsion containing 1.5 percent of methoxychlor.

Milk samples collected at weekly intervals from two herds of dairy cattle treated with a 0.5-percent wettable-powder suspension five and six times during the season were analyzed for organic-chlorine content. Only 3 of 42 samples analyzed showed organic chlorine (0.1 p.p.m.) present.

TDE

The average mean lethal dose of TDE for several laboratory animals was about 2,500 mg. per kilogram of body weight when the insecticide was administered orally. Preliminary feeding tests indicate that the chronic toxicity of TDE is also considerably less than that of DDT.

At Kerrville five sheep, five goats, two cattle, two hogs, and one horse showed no ill effects when treated eight times at 4-day intervals with 1.5-percent emulsion or wettable-powder preparation.

Samples of milk taken at weekly intervals from two herds of dairy cattle treated with TDE were analyzed for their TDE content by the colorimetric method. The animals had been treated five times with a 0.5-percent wettable-powder spray (approximately 2 quarts per animal). Of 20 samples analyzed, 8 were negative and 12 showed TDE present in amounts ranging from 0.1 to 1.2 p.p.m., the average being less than 0.5 p.p.m.

In comparison, all milk samples (total of 26) from herds sprayed with 0.5 percent of DDT contained DDT. The amounts ranged from 0.1 to 2 p.p.m., with an average of about 0.6 to 0.7 p.p.m. When 0.25-percent spray was used, the amount of DDT in the milk ranged from 0.1 to 0.7 p.p.m.

Piperonyl Butoxide

The mean lethal dose of piperonyl butoxide administered by mouth to various laboratory animals was about 12 grams per kilogram of body weight. Its acute toxicity was the lowest for all the insecticides. Pyrethrum, with which this material is usually combined, alone was also relatively nontoxic to warm-blooded animals.

SUGGESTIONS REGARDING THE USE OF THE NEW INSECTICIDES

Suggestions regarding the use of the new materials offered at this time are not necessarily final recommendations. The preliminary nature of the available information regarding their toxicity and performance does not permit definite conclusions to be drawn at present. Livestock growers who contemplate using any of the new materials should follow the recommendations of agricultural workers who are familiar with livestock-pest problems in experiment station, State colleges, and extension services of their State or community.

Benzene Hexachloride

If benzene hexachloride is to be used for controlling any livestock pests, it is recommended that only wettable-powder formulations be used. Products of high gamma-isomer content are the least objectionable from the standpoint of odor. This insecticide should not be applied on dairy animals or on meat animals that are to be slaughtered within 30 days. In view of its toxicity, particularly to young animals, the concentration should be held down preferably to 0.25 percent of the technical material (0.025 percent of gamma isomer) and should not exceed 0.5 percent even when applied to older animals.

Chlordane

No harmful effects on livestock have been noted or reported when chlordane has been applied in insect-control operations. However, since toxic effects have developed in experiments with 1.5-to 2-percent spray applied repeatedly to livestock, additional tests with repeated treatments at lower concentrations should be conducted before recommendations are made for its use on livestock.

Chlordane shows promise for use against house flies in situations where adequate control cannot be obtained with DDT.

Chlorinated Camphene

From the standpoints of economy and efficiency chlorinated camphene is considered promising for the control of a number of livestock pests. However, some deaths of animals, principally young calves, have been reported when this insecticide has been employed in insect-control operations. Since the concentrations required for controlling certain livestock pests are near the toxic level for young animals, further investigations should be conducted with various formulations applied to farm animals of various age groups before suggestions are offered regarding its use against livestock pests.

Methoxychlor

The low toxicity of methoxychlor to animals is an important point in favor of this insecticide. Its acute toxicity is much lower than that of other chlorinated hydrocarbon insecticides. Furthermore, little or none of the material is secreted in milk of treated dairy cattle. Its use is therefore encouraged for controlling insects on dairy animals. Results to date indicate that for horn flies and lice on cattle the insecticide compares rather favorably with other available materials. It is suggested that cattle be treated with a 0.5-percent spray. For control of horn flies about 2 quarts of this spray should be applied to a mature animal. For control of lice from 2 to 6 quarts is recommended. Against horn flies about 3 to 3½ weeks' protection may be expected as compared with about 4 weeks for DDT applied at the same rate. The higher price of the insecticide and possible shorter period of protection may discourage its use on range animals.

Methoxychlor may be considered for controlling house flies under conditions where DDT has not given satisfactory control.

TDE

Although less toxic to animals than DDT, more information is needed on the effectiveness of TDE before it can be recommended for controlling certain livestock pests. The insecticide does provide satisfactory control of horn flies and lice on cattle. For this purpose a concentration of 0.5 percent is suggested.

Piperonyl Butoxide-Pyrethrum Insecticides

Because of the low toxicity of piperonyl butoxide-pyrethrum insecticides to animals, no hazards should ordinarily result from its use. For protection of dairy animals this insecticide preparation should be considered for control of lice, horn flies, stable flies, and tabanids. However, the Bureau does not have sufficient information at this time to suggest the best concentrations to use.